RAZÓN Y PALABRA
Primera Revista Electrónica en Iberoamérica Especializada en Comunicación
http://revistas.comunicacionudlh.edu.ec/index.php/ryp

The scenario of the registry of embedded software in Brazil

El escenario del registro de software embebido en Brasil

O cenário do registro de software embarcado no Brasil

José Aprígio Carneiro Neto

Federal University of Sergipe - Brazil

aprigio.carneiro.ac@gmail.com

Luiz Felipe Costa Silva Carneiro

Federal University of Sergipe - Brazil

luiz_felipe_carneiro@hotmail.com

João Antônio Belmino dos Santos

Federal University of Sergipe – Brazil

santosjab@bol.com.br

Fecha de recepción: 10 de marzo de 2017

Fecha de recepción evaluador: 15 de marzo de 2017

Fecha de recepción corrección: 25 de marzo de 2017

Abstract

Every year, the electronics industry launches thousands of embedded devices, with different shapes and designs. The software used by these devices, called embedded software or firmware, consists of a set of operating instructions embedded in the hardware

of these devices, whose function is to establish communication between their various interfaces. Embedded software accounts for most of the time and cost spent on embedded systems projects due to their complexity, flexibility, and changes throughout the project. The development of embedded software involves the use of modern programming techniques, such as: software reuse and the use of ready code libraries. The use of these techniques significantly reduces the time and costs of the projects, but causes a lot of controversy regarding the copyright infringement of the owners of these codes reused in the projects. In this context, the objective of this article was to analyze the applications for registration of embedded software deposited in Brazil in the database of the National Institute of Industrial Property (INPI), in order to identify the current scenario of intellectual protection of this type of software in the country. The data collection included the use of keywords inserted in the field referring to the "title of the program" of said database. The keywords used in the search were: embedded software, embedded software, embedded system, embedded device and firmware. According to the results obtained, 44 applications for embedded software were deposited in the INPI database, of which 36% were deposited by educational and research institutions. The largest depositors of embedded software belong to the telecommunications area, with 34% of deposits made. Currently, 68% of the applications for registration of embedded software deposited with INPI have been granted. The other 32% are still waiting for your registration.

Keywords: Embedded devices; Embedded Systems; Embedded software; Copyright; Registration; Protection.

Resumen

Cada año, la industria de la electrónica produce en serie miles de dispositivos embebidos, con diferentes formas y diseños. El software utilizado por estos dispositivos, llamado software o firmware integrado, consiste en un conjunto de instrucciones de operación integrado en el hardware de estos dispositivos, cuya función es la de establecer una comunicación entre sus diversas interfaces. El software integrado es responsable de la mayor parte del tiempo y el costo invertido en proyectos de sistemas embebidos, debido a su complejidad, flexibilidad y cambios a lo largo del proyecto. El desarrollo de software integrado implica el uso de técnicas de programación modernos, tales como la reutilización de software y el uso de bibliotecas de código listos. El uso de estas técnicas reduce significativamente el tiempo y costo de los proyectos, pero causa mucha controversia con respecto a la infracción de derechos de autor de los propietarios de estos códigos reutilizados en proyectos. En este contexto, el objetivo de este estudio fue analizar las solicitudes de registro de software embebido presentadas en Brasil en la base de datos del Instituto Nacional de la Propiedad Industrial (INPI) con el fin de identificar la situación actual de la protección intelectual de este tipo de software en el país. La recolección de datos incluye el uso de palabras clave introducidas en el campo

relacionado con el "título del programa" de esa base de datos. Las palabras clave utilizadas en la investigación fueron: software embebido, software embebido, sistemas embebidos, dispositivos integrados y el firmware. De acuerdo con los resultados, se identificaron 44 solicitudes de registro de software embebido archivados en la base de datos toma de fuerza, de los cuales el 36% fueron depositados por las instituciones docentes y de investigación. Los mayores depositantes de software embebido pertenecen a la industria de las telecomunicaciones, con el 34% del depósito efectuado. Actualmente, el 68% de las solicitudes de registro de software embebido presentados ante el INPI había concedido su concesión. El otro 32% restante aún están a la espera que se conceda.

Palabras clave: Dispositivos embebidos; Sistemas embebidos; Software embebido; Derechos de autor; Registro; Protección.

Resumo

Anualmente, a indústria de eletrônicos lança no mercado milhares de dispositivos embarcados, com diferentes formas e projetos. O software utilizado por esses dispositivos, denominado de software embutido ou firmware, consiste em um conjunto de instruções operacionais embutidas no hardware desses dispositivos, cuja função é estabelecer a comunicação entre as suas diversas interfaces. O software embarcado é responsável pela maior parte do tempo e custo gasto nos projetos de sistemas embarcados, devido a sua complexidade, flexibilidade e alterações ao longo do projeto. O desenvolvimento de software embarcado envolve o uso de técnicas modernas de programação, tais como: a reutilização de software e o uso de bibliotecas de códigos prontos. A utilização dessas técnicas reduz significativamente o tempo e os custos dos projetos, mas provoca muita polêmica com relação à violação de direitos autorais dos proprietários desses códigos reutilizados nos projetos. Diante desse contexto, o objetivo deste artigo foi analisar os pedidos de registro de software embarcados depositados no Brasil na base de dados do Instituto Nacional da Propriedade Industrial (INPI), a fim de identificar o cenário atual da proteção intelectual deste tipo de software no país. A coleta de dados incluiu o uso de palavras-chave inseridas no campo referente ao "título do programa" da referida base de dados. As palavras-chave utilizadas na pesquisa foram: software embarcado, programa embarcado, sistema embarcado, dispositivo embarcado e firmware. De acordo com os resultados obtidos, foram identificados 44 pedidos de registro de software embarcados depositados na base de dados do INPI, dos quais 36% foram depositados por instituições de ensino e pesquisa. Os maiores depositantes de software embarcados pertencem à área de telecomunicações, com 34% dos depósitos feitos. Atualmente, 68% dos pedidos de registro de software embarcados depositados no INPI tiveram a sua concessão deferida. Os outros 32% restantes ainda aguardam a sua concessão.

Palavras-chave: Dispositivos embarcados; Sistemas embarcados; Software embarcado; Direitos autorais; Registro; Proteção.

Introduction

The emergence of embedded systems has provoked a real revolution in the software market by developing applications designed to meet the complex levels of requirements and requirements specified by these devices.

The development of these embedded applications, called embedded software or firmware, has become a complex activity, demanding from software developers a fast and efficient production that can meet the growing demand of this market.

Currently, embedded software is developed with the aid of high level programming languages that allows the use of modern programming techniques, such as: reusing codes from other projects and creating code libraries specific to the development of embedded applications.

The use of these programming techniques guarantees more agility in the process of developing the embedded software, reducing the execution time of the projects, as well as their costs. However, they need to be used with great caution in order to avoid copyright and intellectual property infringement by the authors of these reused codes.

Over the years technological advances in the area of software development have led the authors of these computational tools and the software industry to seek protection mechanisms that can ensure the rights of their creations (Oliveira & Feres, 2016).

One of the biggest problems facing the software industry is the issue of piracy. Software piracy violates all copyright and may manifest itself through the practice of a series of irregular conduct, such as: forgery, illegal copying, misuse of software without obtaining its license to use, commercialization without the prior authorization of the author, among others. In addition to piracy, another form of software copyright infringement occurs through reverse engineering or software reengineering where ready program codes are reused in the development of other software without the consent of their respective authors (Santos, 2008).

In Brazil, discussions about software protection are not recent. Since 1986, the Brazilian government has been investing in research and studies on the subject, in order to identify mechanisms that can guarantee the protection of this modality of intellectual property. The first Brazilian legislation to deal with the regulation of the rights of computer programs was Law No. 7.646/87, which had the purpose of establishing in Brazil the obligation to protect computer programs by means of copyright. However, only

in 1998, with the promulgation of the Software Law (Law No. 9,609/98), the country entered definitively the international scenario of software protection, being in line with the main international treaties related to the issue of software protection.

In addition to the Software Law, other legislation that protects computer programs is the Law on Copyright and Related Laws (Law No. 9,610/98), both of which have legal protection mechanisms for computer programs and addresses issues related to their commercialization and Penalties and criminal offenses in the event of their violation (Wachowick, 2012).

The responsibility for the supervision of these laws, in the scope of intellectual protection, belongs to INPI (National Institute of Industrial Property). In addition to this function, the agency is also responsible for analyzing and granting the title of protection assigned to programs those computers, called software registration.

In this context, the purpose of this article is to analyze the applications for registration of embedded software deposited in Brazil in the database of the National Institute of Industrial Property (INPI), in order to identify the current scenario of intellectual protection of this type of software in the country.

Theoretical Review

The embedded software had its origin in the 60's and correspond to a set of operating instructions, programmed and stored directly in the hardware of an electronic device, called the embedded system (Oliveira & Andrade, 2006).

Embedded systems are electronic devices developed from the junction of a hardware with software (Wolf, 2012) and are present in an infinity of electronic equipment developed for the modern world, in order to assist us in the execution of several tasks of our daily life (Pressman, 2006).

The first embedded software was developed with the aid of a specific programming language for electronic devices, called Assembler. With the use of the Assembler, each electronic device had its own programming code, and its portability to another device was not possible, thus determining that each project had a unique code (Barr, 2009).

Since the 1970s, with the emergence of new programming languages and the creation of specific code libraries for the development of embedded applications, the programming of these devices began to be made with the aid of the programming language C (Ball, 2002).

The programming languages C and Assembler were very important in the development of the first embedded applications, considering that both were able to deal

with the hardware limitations imposed by the electronic devices, such as: processing, memory and energy (Barr, 2009).

With the introduction of high-level languages, such as C ++, Java, PHP, Python and others, the embedded software market has gained more agility and security by reusing codes in embedded applications development projects (Corsaro & Cytron, 2003).

Over the years, thousands of embedded systems have been launched on the market in a variety of forms and designs, involving various types of electronic components, software reuse and new programming codes (Taurion, 2005).

Embedded software is responsible for most of the time and cost of embedded systems projects, given its complexity, flexibility, and changes throughout project execution (Edwards, Lavagno, Lee & Sangiovanni-Vincentelli, 1997). In addition, they have some characteristics that differentiate them from the traditional software used by microcomputers, among them we can highlight (Berger, 2002): the accomplishment of specific tasks for which they were programmed; Support for various types of processors; Their sensitivity to costs; Can be stored in non-volatile memory (ROM) (read-only memory or flash) depending on your application, and its failures are more severe than traditional software.

The development of embedded software involves different characteristics, due to the purposes of its use and the nature of its operations (Lee, 2002). For this reason, software developers in this area have been investing in the use of modern and efficient programming techniques that can accelerate productivity and make projects more economical (Sangiovanni-Vincentelli, Carloni, De Bernardinis & Sgroi, 2004).

The main programming techniques used in embedded software development projects are: the reuse of codes, the creation of libraries of specific functionalities for these applications and the use of software components (Roselino, 2006).

The software components used in the development of embedded systems are ready codes that encapsulate several functionalities, behaving as an independent unit in relation to the other components of the system, and can be used in the development of a larger system. In order to use the software components, it is important that an infrastructure is initially established that serves as the basis and rule for its communication with the other modules of the system, thus facilitating the fulfillment of the requirements of larger system functionalities. In addition, software components need to be easily and quickly integrated with other components of the system with the least possible code adaptation or change through their interfaces (Zhang, Benini & Micheli, 2001).

The reuse of ready code and the use of software components make development activities a simple assembly activity, greatly reducing project development time and costs. The greater its use in projects, the greater the productivity gain and the lower the cost of the project (Szyperski, 2002).

The use of these programming techniques has generated much controversy regarding the issue of copyright infringement of authors of the codes reused in the projects (Andrade, Tigre, Silva, Silva, Moura, Oliveira & Souza, 2007). In 2012, this controversy increased, following the launch of a public consultation conducted by the National Institute of Industrial Property (INPI), which sought the elaboration of guidelines that could assist the experts of this body in the analysis of patent applications involving inventions that make use of Embedded software or computer programs themselves (Abrantes, 2012).

For Abrantes (2012), the granting of patents for inventions involving embedded software is admitted by INPI, because the software is executed directly in an electronic device that is completely dedicated to the system it controls. Thus, inventions that use embedded software have two forms of protection: (i) copyright for embedded software and (ii) patent law, for the invention.

In Brazil, all types of software are protected by two laws: the Copyright and Related Rights Law (Law No. 9,610/98) and the Software Law (Law No. 9,609/98). Both have legal mechanisms that address the protection and rights attributed to computer programs (Wachowicz, 2012).

Registration of software in Brazil is not mandatory, but may serve as an important protection mechanism for software developers and companies working in this area. In terms of its scope, the software registry has international recognition among countries that are part of the Agreement on Trade-Related Aspects of Intellectual Property Rights, signed in 1994 in Uruguay. Therefore, foreign programs do not need to be registered in Brazil, except to guarantee the protection of the parties involved in the assignment of rights (INPI, 2016).

The Brazilian agency responsible for granting the registration of software is INPI. In order to register the software, it is necessary that the software owner or prosecutor follow a few steps, which include the mandatory completion of a specific documentation, available on the agency's website, as well as the payment of a collection guide, called GRU. The documentation required for the software registration process with the Brazilian agency is divided in two parts: formal documentation and technical documentation. All forms and document templates used in the process of requesting a software registration can be found on the institution's website (INPI, 2016).

In the case of formal documentation, the following documents are required: (INPI, 2016):

1) A form entitled "Application for Computer Program Registration", which must be duly completed and signed by the program holder;

2) Proof of payment of the due remuneration (GRU);

3) Authorization to copy the technical documentation, duly completed and signed by the program owner, if the technical documentation is presented on CD/DVD, GRU should be submitted for service 722;

4) When the holder is different from the author of the program, the following documents are necessary:

    a) Document of assignment of economic rights, or;

    b) Employment contract, service provision, statutory, scholarship or internship, in fear of the caput and §1. Of art. 4º. Of Law no. 9.609/98.

5) If the holder of the program is a legal entity, the social contract must be presented in order to prove the legitimacy of the legal representative of the legal entity;

6) In the case of a derived computer program, authorization document of the original program holder, pursuant to art. 4º. Of Decree no. 2,556/98, according to the model of the Authorization Document of the Holder for Derivation;

7) Letter of attorney in case the holder needs to be represented by another person.

In the case of technical documentation, the following items are required:

1) Presentation, in two copies, of partial or complete listing of the source code or object, in addition to the specifications and flowcharts of the computer program. Data can be recorded in PDF format on CD or DVD;

2) Both discs should be contained in strong plastic packaging and shipped separately inside plastic envelopes. One envelope will be stored by INPI and another will be returned to the sender;

3) The technical documentation that is received without the authorization to copy will not be accepted;

4) The lines of code are protected and cannot be revealed, and stored inside a special envelope inside the INPI security file. This can only be opened at the request of the holder or by legal order.

The entire process of registration of software with the INPI can be accompanied by the website of the agency or by a magazine, called RPI (Intellectual Property Magazine) published every Tuesday (INPI, 2016).

According to the INPI, the regulatory period between the deposit of the application for registration of software and the issuance of its certificate is 90 days, and at the time of deposit the software is granted its registration number, which can be used in the communications about it, informing the existence of the registry (INPI, 2016).

In order to obtain a software registration it is necessary that the software has originality requirements and its source code is kept secret until its registration is granted. The registration title of the software is valid for 50 years counted from the date of its deposit with the INPI and grants its owners exclusive rights over the use and commercialization of their creations, as well as to prevent third parties from using their creations (Barbosa, 2013).

Methodology

The research carried out in this article had an exploratory character and initially counted on a bibliographical review on the subject, carried out through researches in scientific articles, books, theses, dissertations, magazines, monographs, among others.

Then, a survey was carried out of the requests for records of embedded software, deposited in the database of the National Institute of Industrial Property (INPI).

The data collection took place in October 2016 and used as a search strategy the combination of keywords inserted in the "title of the program" field of the cited database. The keywords used in the searches were: "embedded software", "firmware", "embedded program", "embedded system" and "embedded device".

In the searches, the keywords were given the quotation delimitation (""), in order to find more specific and precise results related to the searched topic.

Finally, the collected information was selected, tabulated and analyzed quantitatively according to the following criteria: annual evolution of the requests for registrations of embedded software, classification of embedded software in its field of application, programming languages used in the development of embedded software, classification of embedded software in terms of the type of program developed, profile of software depositors embedded in the INPI database and number of concessions of registrations of embedded software deferred in Brazil.

Results and Discussion

According to the search criteria used in this research, 46 requests for embedded software registrations were identified initially in the INPI database. After a previous analysis of these deposits, it was verified the existence of 02 applications for registration in duplicate. These requests were excluded from the survey, leaving only 44 applications for registration of embedded software for analysis, as shown in Table 1.

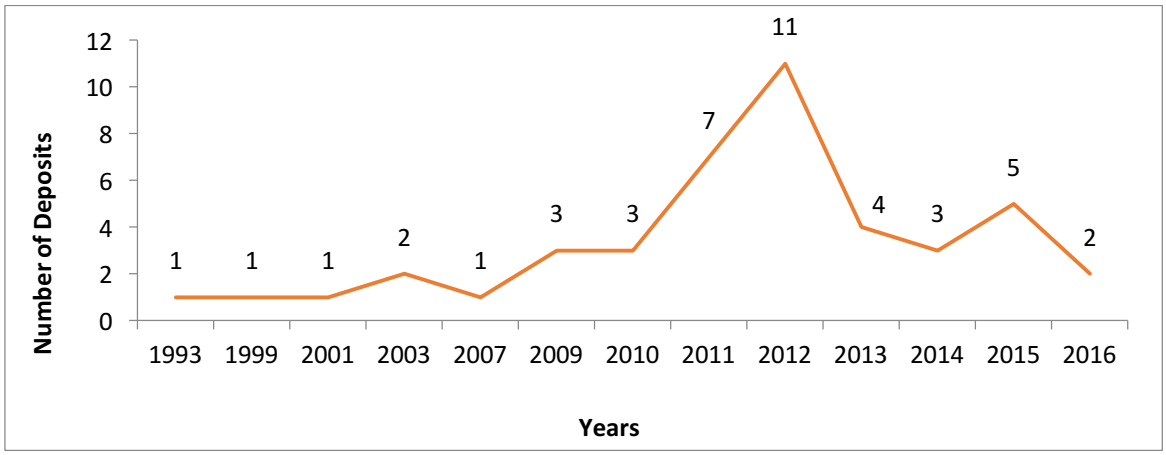
Table 1 - Number of software registration applications filed with INPI.

Keywords	Number of Software Registration Requests
Embedded Software	04
Firmware	33
Embedded program	01
Embedded system	05
Embedded device	01
Total	**44**

Source: Data collected in the database of the INPI (2016).

Based on the research results, the first application for registration of embedded software deposited in the INPI database occurred in 1993 and was requested by a Brazilian company named Fyber Equipamentos Eletrônicos Ltda. The claim of the software requested by the company is for an application for the area of automotive electronics, developed in the Assembler programming language, titled "Black Bird Firmware". It is worth mentioning that to date, the application for registration of software related to this application is under analysis by the Brazilian agency, and no information or pending information regarding it is found.

Figure 1 - Annual evolution of deposits of embedded software at INPI.



Source: Data collected in the database of the INPI (2016).

In Figure 1, we can see that during the period from 1993 to 2016, the volume of applications for registration of embedded software deposited in the INPI database was low, when compared to the volume of deposits made by the countries that invest most in the development of software Related to this technology, such as: China, United States, Republic of Korea, Japan, Canada and United Kingdom, as we can see in Table 2.

Table 2 - Countries that invest most in the development of embedded software.

Countries	Number of Deposits
China	1893
United States	1674
Republic of Korea	393
Japan	215
Canada	117
United Kingdom	62

Source: Data collected in the database of the WIPO (2016).

It is worth mentioning that the search criteria used in the consultations conducted in the WIPO database followed the same search criteria described in the methodology presented in this article.

In Brazil, the most outstanding years in relation to the number of applications filed for software registration were: 2011 and 2012, with respectively 7 and 11 deposits each. The other periods analyzed did not present significant results in relation to the number of software registration requests of this nature (see Figure 1).

One of the factors that contributed to the increase in the deposit rate of software registrations in the period 2011 to 2012 was the launching of the Brazilian Big Plan (PBM) by the Brazilian government in 2011. The purpose of the PBM was to stimulate innovation and production Increasing the competitiveness of industry in domestic and foreign markets, through the adoption of public policies to stimulate investment in infrastructure and tax relief, which benefited the entire productive system of the country, contributing to a general reduction of the costs of inputs and Products from 2011 to 2014 (IEDI, 2011).

Among the main measures adopted by the PBM, we can highlight: the exemption of investments and exports; The extension and simplification of investment and export financing; The increase of resources for innovation; Improvement of the regulatory framework for innovation; Stimulating the growth of micro and small businesses; The strengthening of trade defense; The creation of special schemes for the aggregation of value and technology in the productive chains; And the regulation of the government procurement law to stimulate production and innovation in the country (ABDI, 2013).

The targets stipulated by the PBM included, among other things: an 18.4% increase in investments in the country's fixed capital; The increase of the Gross Domestic Product (GDP) to 23% by 2014; The rise in private spending on science and technology from 0.55% to 0.9%; And the expansion of the industry's share in GDP, from 18.3% to 19.5%. Despite all these actions, the Brazil Major Plan did not have concrete measures to encourage the country's technological development (IEDI, 2011).

Regarding the classification of software by field of application, we can observe that the largest volumes of software registration applications deposited in the INPI database belong to the following areas of activity: telecommunications (TC-02) - 22.7%; data processing (IF-10) - 13.6%; therapy and diagnosis (SD-06) - 11.4%; and financial system (FN-03) - 9.1% (see Table 3).

According to data from ABINEE (Brazilian Association of the Electrical and Electronics Industry), the revenues of the electric and electronic industry in 2015 for the IT and telecommunications sectors were 30,170 and 28,309 million real, respectively. Exports of electrical and electronic products to these sectors moved 267 (IT) and 224 (Telecommunications) respectively in the same period. One of the most exported products in the electrical and electronics sector was the electronics shipped with 565 million dollars (ABINEE, 2016).

Table 3 - Classification of embedded software by field of application.

Fields of Application	Description of Fields of Application	Number of Deposits	% of Total
AD-09	Property Management	01	2,3%
CO-04	Communication	02	4,5%
EN-02	Power Features	01	2,3%
EN-04	Technology and Energy	03	6,8%
EN-05	Electronic Engineering	02	4,5%
FN-02	Private Finance	01	2,3%
FN-03	Financial System	04	9,1%
FQ-12	Spectroscopy	01	2,3%
IF-02	Documentation	01	2,3%
IF-10	Data processing	06	13,6%
IN-02	Technology	01	2,3%
SD-06	Therapy and Diagnostics	05	11,4%
SD-09	Biomedical Engineering	01	2,3%
TC-01	Telecommunications	03	6,8%
TC-02	Telecommunications Systems	10	22,7%
TC-03	Telecommunication Engineering	02	4,5%
Total		**44**	**100%**

Source: Data collected in the database of the INPI (2016).

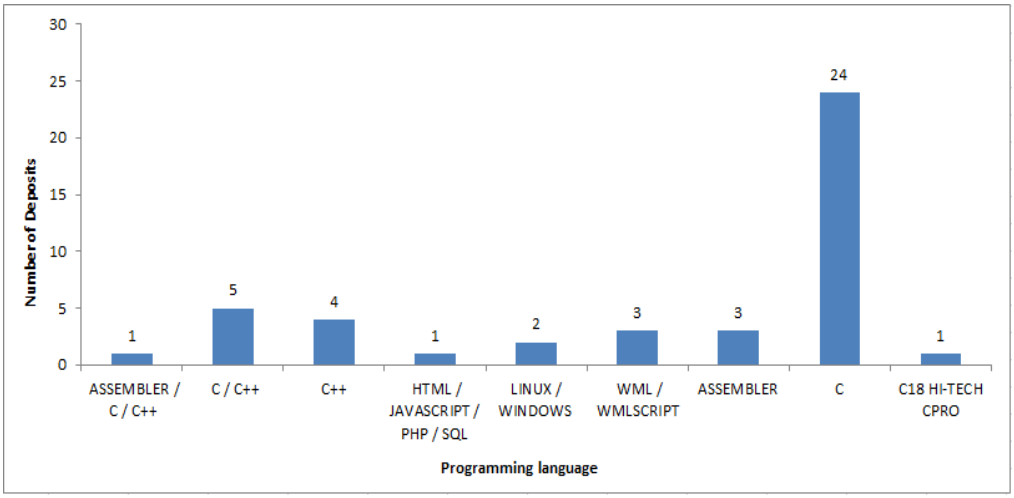
The allocation of the software in the field of application is carried out by means of a previous analysis of the descriptions of its functionalities fulfilled in the forms of request of registry of software submitted to the INPI by its respective applicants. Currently, the body has a list of 35 types of application fields, which are subdivided into several areas of activity.

According to the research results, the programming languages most used in the development of embedded applications deposited in the INPI database were: the C language (24 deposits); C ++ (04 deposits), Assembler (03 deposits); and the WML handling language (03 deposits). In addition, we can observe the association of more than

one programming language used in the development of these applications, such as the junction of C with C ++, which obtained a total of 05 deposits (see Figure 2).

Another important fact that deserves attention in this research was the appearance of two embedded software that had their programming languages erroneously classified as Linux and Windows (see Figure 2). It is believed that an error must have occurred at the moment of filling the information in the database of the organ, since both are operating systems and not programming language.

Figure 2 - Programming languages used by embedded software.



Source: Data collected in the database of the INPI (2016).

With regard to programming languages, the research also identified the presence of two new programming languages used in embedded software development: the WML (Wireless Markup Language) manipulation language and the HI-TECH C Compiler. The WML language is used in the development of applications for mobile devices, such as: cell phones, PDAs, among others. This language allows programming optimization for the small screens used by these devices. The HI-TECH C compiler (C18 - CPRO) is used in the development of embedded applications for microcontrollers belonging to the PIC18 family.

Regarding the classification by type of program, we can observe that the largest volumes of applications for the registration of embedded software are concentrated in four areas: data communication with 18.2%, tools to support the development of systems with 15, 9%, biomedical instrumentation with 11.4% and cryptography with 9.1%, as shown in Table 4.

Table 4 - Classification of embedded software by field of application.

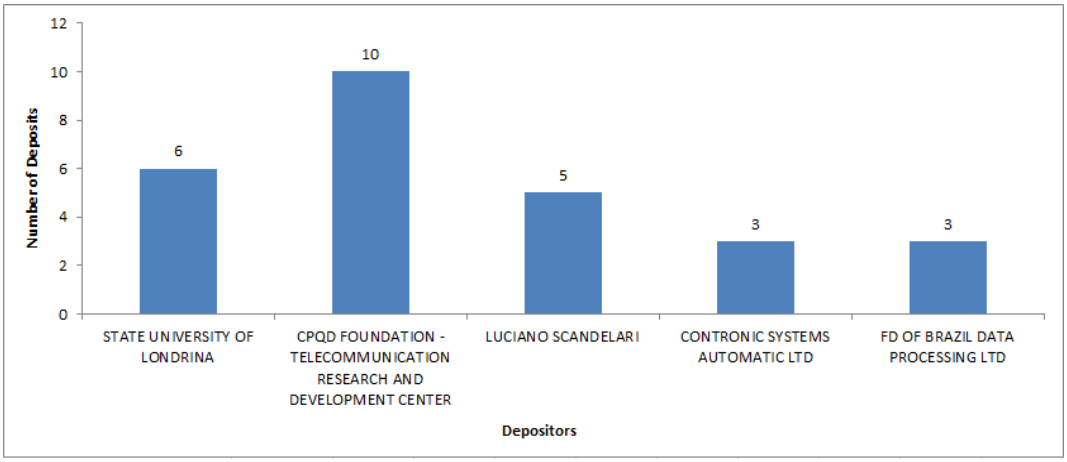
Types of Programs	Description of Program Types	Number of Deposits	% of Total
AP-01, IA-02	Applications, Specialist System	01	2,3%
AT-01	Automation	02	4,5%
AT-03	Commercial automation	01	2,3%
AT-05	Industrial automation	01	2,3%
AT-08	Automotive Electronics	01	2,3%
CD-01	Data communication	08	18,2%
CD-04	Device and Peripheral Management	02	4,5%
DS-01	System Development Tools	07	15,9%
ET-02	Games	02	4,5%
GI-02	Database Manager	01	2,3%
IA-01	Artificial intelligence	01	2,3%
IT-02	Test and Measurement Instrumentation	02	4,5%
IT-03	Biomedical Instrumentation	05	11,4%
PD-03	Encryption	04	9,1%
SO-02	Input and Output Interface	02	4,5%
SO-04	Communication Interface	01	2,3%
SO-07	Process Controller	02	4,5%
TI-03	Data Transmission	01	2,3%
Total		**44**	**100%**

Source: Data collected in the database of the INPI (2016).

In Brazil, the ranking of the largest depositors of embedded software is led by the CPQD Foundation (Research and Development Center in Telecommunications) with 10 deposits, followed by the State University of Londrina with 06, by the independent inventor Luciano Scandeli with 05 deposits and by Contronic companies and FD do Brazil, with 03 deposits each (see Figure 3). The other 17 deposits were made in a unitary manner by their respective inventors.

The survey carried out at the INPI database did not identify any applications for registration of embedded software made by foreign depositors, all of which had Brazil as its country of origin.

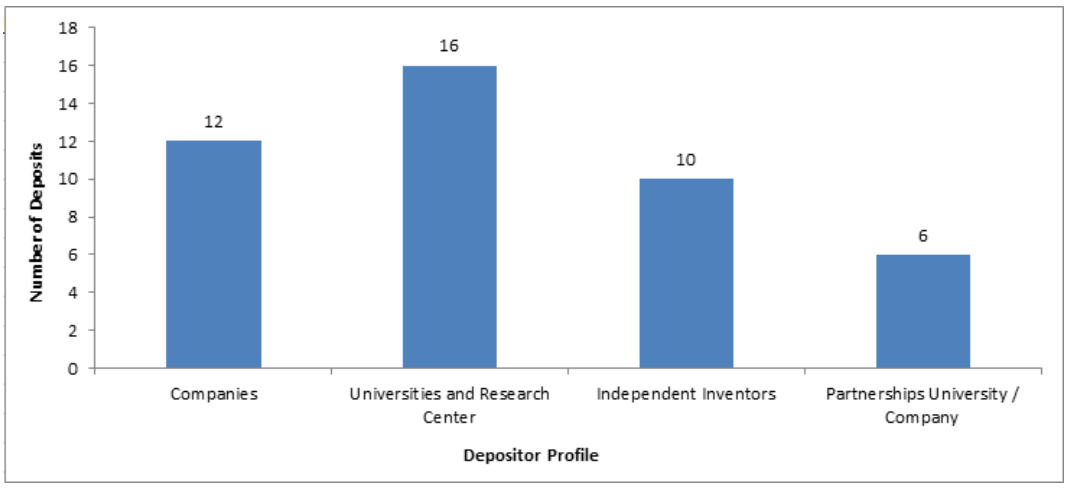
Figure 3 - Ranking of the largest software depositors on the INPI.



Source: Data collected in the database of the INPI (2016).

With regard to the profile of embedded software depositors in Brazil, we can highlight that 36% are formed by Universities and Research Center; 27% by companies; 23% by independent inventors and 14% by the partnership between universities and companies (see Figure 4).

Figure 4 - Profile of depositors of embedded software in INPI.

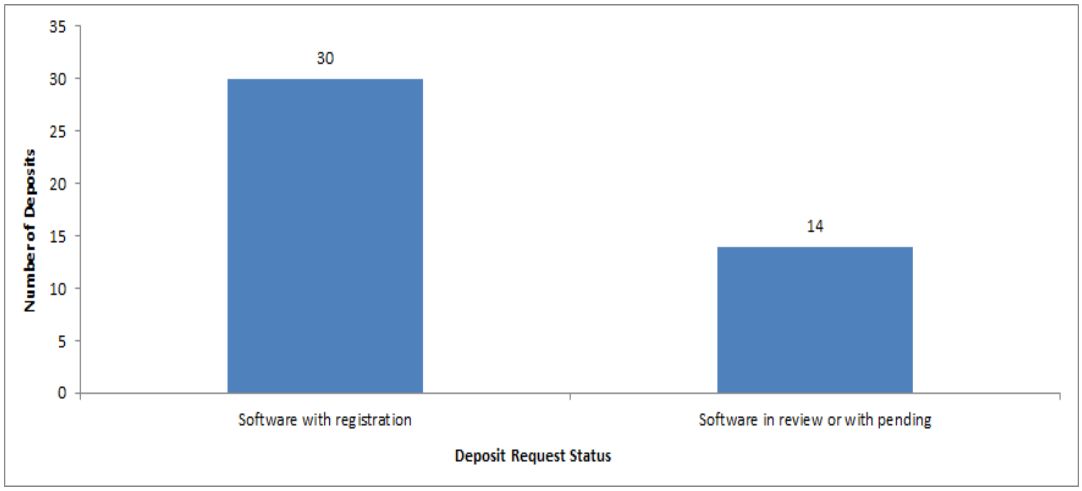


Source: Data collected in the database of the INPI (2016).

Of the 44 applications for registration of embedded software deposited at the INPI, 68% have already been granted registration. The other 32% are awaiting the analysis of the agency or still have some kind of pending with the same (see Figure 5).

The main pending issues identified in the analysis of applications for registration of software with INPI were: problems in the authentication of the power of attorney and title of the different program in the authorization to copy the technical documentation.

Figure 5 - Concession of embedded software registrations by INPI.



Source: Data collected in the database of the INPI (2016).

In Table 5, we can observe the time that INPI researchers took to analyze and grant the 30 applications for registration of embedded software approved by the agency.

Table 5 - Average time for analysis and concession of embedded software registrations.

Number of Requests for Records.	Deposit Date	Date of Grant of Registration	Order Analysis Time (In Days)
02665-6	16/08/1999	18/01/2011	4112
05087-0	08/04/2003	02/02/2010	2454
08119-2	14/05/2007	13/10/2009	869
09475-1	11/02/2009	09/02/2010	358

10210-3	12/11/2009	15/06/2010	213
10252-5	17/12/2009	25/11/2014	1778
10885-2	30/07/2010	01/02/2011	181
11177-1	09/11/2010	22/02/2011	103
11178-3	09/11/2010	22/02/2011	103
11851-4	11/04/2011	01/11/2011	200
12123-4	29/07/2011	17/01/2012	168
12447-2	07/10/2011	27/03/2012	170
13158-0	25/04/2012	05/12/2012	220
13312-5	30/05/2012	05/12/2012	185
13875-0	01/11/2012	09/09/2014	668
13876-2	01/11/2012	02/09/2014	661
13877-4	01/11/2012	09/09/2014	668
13900-1	23/11/2012	13/08/2013	260
BR 51 2013 001001 2	18/09/2013	04/11/2014	406
BR 51 2013 001002 0	18/09/2013	04/11/2014	406
BR 51 2013 001004 7	18/09/2013	04/11/2014	406
BR 51 2013 001320 8	29/11/2013	23/12/2014	384
BR 51 2014 001580 7	18/12/2014	07/06/2016	529
BR 51 2014 001581 5	18/12/2014	29/12/2015	371
BR 51 2015 000373 9	29/04/2015	03/05/2016	364
BR 51 2015 000375 5	29/04/2015	29/03/2016	330
BR 51 2015 001097 2	30/09/2015	08/03/2016	158
BR 51 2015 001098 0	30/09/2015	08/03/2016	158
BR 51 2015 001099 9	30/09/2015	08/03/2016	158
BR 51 2016 000770 2	24/06/2016	08/11/2016	134

Source: Data collected in the databases of the INPI (2016).

In Brazil, 60% of the embedded software that obtained its software registration with INPI was evaluated in a period of approximately 1 year, an evaluation time

considered satisfactory for products related to the technology area and for a developing country. The remaining 40% had their application for registration reviewed and granted over a period of more than 02 years, a very high time for an area that demands speed of delivery and efficiency in the quality of its products.

The requests for software registrations that suffered the most from their evaluations and concessions were: 02665-6, approximately 11 years and 04 months; 05087-0, at 06 years and 08 months; 08119-2, with 02 years and 04 months and the record 10252-5, with 04 years and 09 months. Among the requests for registrations mentioned, the only one that presented any type of problem or pending in its concession process was the application number 10252-5. For the others, no evidence was found in the organ database to justify the delay in their evaluation.

Final Considerations

In Brazil, between the period of 1993 and 2016, only 44 software registry warehouses registered in the INPI database were registered, with most of these applications deposited by universities and research centers. The participation of software companies and independent inventors in this scenario was very discreet, although this type of technology is present in most of the electronic devices used in our daily lives.

The market for embedded software development is very comprehensive and competitive, especially in the areas of information technology and telecommunications.

The development of embedded software has become quite complex, with high integration levels between the hardware and software parts that make up the embedded electronic devices.

In the current scenario there are several programming languages that can be used in the development of these embedded applications. During the research in the INPI database, we can observe predominance by the use of the C language, because it is one of the most well-known languages in the software development market and for allowing the use of advanced programming techniques, such as: The reuse of software and the use of code libraries specific to that area.

Another point that draws attention in this research was the high time for the analysis and granting of software registrations by INPI researchers. According to the survey data, only 30% of the software registrations granted by the agency are within the deadline established by it, which is approximately 06 months between the date of filing and the issuance of the software registration certificate. The other 70% have very high analysis deadlines for products related to the technology area. In the INPI database, we can still find software registration applications that have been waiting for an analysis of the agency for more than 04 years. When it comes to technology, high time to analyze

and grant software registration are considered inadmissible, since the technology will become easily obsolete for the market.

Given this scenario, we can conclude that the country needs to invest more in the production and intellectual protection of embedded software in order to avoid unfair market competition and ensure the intellectual rights of the holders of these applications. In addition, it is necessary for INPI to reevaluate its deadlines for the analysis and granting of software registrations, avoiding financial and intellectual losses for the authors of such software.

References

Abrantes, A. (2012). *Diretrizes de Exame de invenções implementadas por programas de computador*. DIRPA/INPI/Brazil. São Paulo. Available at: http://www.redetec.org.br/inventabrasil. Accessed on: 15 October. 2016.

Andrade, E.; Tigre, P. B.; Silva, L. F.; Silva, D. F.; Moura, J. A. C.; Oliveira, R. V.; Souza, A. (2007). *Propriedade intelectual em Software: o que podemos apreender da experiência internacional?* Revista Brasileira de Inovação, Rio de Janeiro, v. 6, n. 1, p. 31-53, jan./jun.

ABDI. (2013). Agência Brasileira de Desenvolvimento Industrial. *Brasil Maior: Inovar para Competir. Competir para Crescer*. Balanço Executivo – 2 anos. Available at: http://www.abdi.com.br/Estudo/PBM%20-%20Balan%C3%A7o.pdf. Accessed on: 05 October. 2016.

ABINEE. (2016). Associação Brasileira da Indústria Elétrica e Eletrônica. *Comportamento da indústria elétrica e eletrônica: ano 2016. Projeções para 2017.* Available at: http://infoportobrasil.com.br/estudoparecer/comportamento-da-industria-eletrica-e-eletronica-ano-2016-projecoes-para-2017. Accessed on: 10 October. 2016.

Barbosa, D. B. (2013). *Tratado de propriedade intelectual: a proteção do software, do sigilo dos testes para registro de comercialização e topografia de circuitos integrados.* Rio de Janeiro, Lumen Juris. Brasil.

Ball, S. R. (2002). *Embedded Microprocessor Systems: Real World Design*. 3rd edition. Publisher: MCPros, EUA.

Barr, M. (2009). *Programming embedded systems in C and C++*. Published: " O'Reilly Media, Inc.". Sebastopol, USA.

Berger, A. S. (2002). *Embedded Systems Design – An Introduction to Process, Tools & Techniques*. CMP Books, USA.

Corsaro, A., & Cytron, R. K. (2003). Efficient memory-reference checks for real-time java. In *ACM SIGPLAN Notices* (Vol. 38, No. 7, pp. 51-58). ACM. New York.

Edwards, S., Lavagno, L., Lee, E. A., Sangiovanni-Vincentelli. A. (1997). *Design of Embedded Systems: Formal Models, Validation and Synthesis*. IEEE, vol. 85, No 3, pp. 366–390.

IEDI. (2011). Instituto de Estudos para o Desenvolvimento Industrial. Uma análise do Plano Brasil Maior. Available at: http://www.aeb.org.br/userfiles/file/Carta%20IEDI%20n%C2%BA%20486%20-%20Uma%20An%C3%A1lise%20do%20Plano%20Brasil%20Maior(1).pdf. Accessed on: 10 October. 2016.

INPI. (2016). Instituto Nacional de Propriedade Industrial. Available at: http://www.inpi.gov.br/portal/. Accessed on: 10 October. 2016.

Lee, E. A. (2002). Embedded software. *Advances in computers*, *56*, 55-95. M. Zelkowitz, Editor, Vol. 56, Academic Press, London.

Oliveira, A. S. & Andrade, F. S. (2006). *Sistemas embarcados: hardware e firmware na prática*. Editora Érica Ltda.

Oliveira, J. V. & Feres, M. V. C. (2016). *Softwares livres e governo: um filete de água no moinho digital*. Revista Quaestio Iuris. v 09, n. 2, p. 620-636, Rio de Janeiro.

Pressman, R. S. (2006). *Engenharia de Software*. 6. Ed. – São Paulo: McGraw-Hill.

Roselino, J. E. S. (2006). *A indústria de software: o "modelo brasileiro"*. 228 f. Tese (Doutorado em Ciências Econômicas) - Universidade Estadual de Campinas (UNICAMP). Instituto de Economia, Campinas, SP. Available at: http://www.bibliotecadigital.unicamp.br/document/?code=vtls000380464. Accessed on: 10 October. 2016.

Sangiovanni-Vincentelli, A.; Carloni, L. P., De Bernardinis, F.; Sgroi, M. (2004). *Benefits and challenges for platformbased design*. In: DAC '04: Proceedings of the 41st annual conference on Design automation. New York, NY, USA: ACM, pp. 409–414.

Santos, M. J. P. (2008). *A proteção autoral de computador*. Rio de Janeiro: Lumem Juris.

Szyperski, C. (2002). *Component Software – Beyond Object-Oriented Programming*. Second Edition.

Taurion, C. (2005). *Software Embarcado - A nova onda da Informática*. Brasport.

Wachowicz, M. (2012). *Consulta pública: a patenteabilidade do software no Brasil*. Boletim do Grupo de Estudos de Direitos Autorais e Informação – GEDAI, v. 2, ano 03, abr. 2012.

WIPO. (2016). World Intellectual Property Organization. Available at: http://www.wipo.int/portal/en/index.html. Accessed on: 17 October. 2016.

Wolf, M. (2012). *Computers as components: principles of embedded computing system design*. 3rd. Elsevier.

Zhang, T.; Benini, L.; Micheli, G. D. (2001). *Component selection and matching for IP-based design.* Available at: http://theory.stanford.edu/~tingz/papers/date01/date01.pdf. Accessed on: 20 October. 2016.